Final Project Report for

TRAFFIC STUDIES, EVALUATIONS AND ITS PLANNING FOR LINCOLN'S ARTERIAL STREET SYSTEM 1999-2000 (PHASE II)

VOLUME II: ITS COMMUNICATION AND USER NEEDS ANALYSIS

Submitted to

CITY OF LINCOLN, NEBRASKA
PUBLIC WORKS & UTILITIES DEPARTMENT

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1.0 INTRODUCTION

During the initial phase of the Traffic Studies, Evaluations and Intelligent Transportation Systems (ITS) Planning Project, short and long term communication plans were developed in addition to performing signal timing analyses. Several meetings were conducted to conceptualize the needs and requirements of communication systems in support of the overall traffic control system and ITS needs. During the current phase of the project, the focus has been on the identification of high-level communication requirements, including discussions with various communication providers, and the development of techniques and approaches for the deployment of the overall City of Lincoln ITS communication network.

In addition to the communication analysis, this report presents a summary of the ITS User Needs that have been identified for the City of Lincoln. The development of the User Needs will set the stage for the City's future ITS studies and can be used at a later time in developing an implementation plan for ITS in the City of Lincoln.

The following sections are discussed within this report:

Section 2: Priority Corridors presents a summary of the priority corridor analysis.

Section 3: City of Lincoln ITS Communication Network will present the updated existing, short- and long-term ITS communication network for the City of Lincoln.

Section 4: ITS Communication Support and Coordination presents a summary of our discussions with the various communication providers in the City of Lincoln area with regard to establishing possible partnerships.

Section 5: ITS User Needs summarizes ITS User Needs identified within the City of Lincoln.

Section 6: Summary This section provides a summary of the work completed to date and the next steps involved in making ITS a reality in the City of Lincoln.

2.0 PRIORRITY CORRIDORS

A number of streets have been identified as potential priority corridors. Priority corridors are those roadways that have or will have a significant role in the transportation network. This is based on the importance of roadways to the existing transportation system and roadways deemed important in the future transportation system as determined by the City/County's long-range transportation plan. The following is a descriptive list of the priority corridors, which are also illustrated in **Figure 1**. The priority corridors were developed for three time periods; short-term (0-5 years), mid-term (6-10 years), and long-term (11+ years).

North-South Corridors

- *East Beltway:* Proposed beltway east of Lincoln connecting I-80, Nebraska Highway 2 and the South Beltway. Currently, the East Beltway is in the study phase, investigating three alignment alternatives.

- *I-180:* Four-lane, interstate spur connecting I-80 to downtown Lincoln.

- *84th Street:* Four-lane arterial from approximately Pioneers Boulevard to U.S. Highway 6; two-lane arterial south of Pioneers Boulevard. Plans are to provide four lanes south to Nebraska Highway 2 by 2004. Currently, 84th Street is the easternmost north-south arterial within the City limits.

- *56th Street:* Two-lane arterial from Fremont Street to South Street. Four-lane arterial from South Street to Old Cheney Road and a two-lane arterial south of Old Cheney Road.

- *27th Street:* Only continuous arterial that connects I-80 on the north to south of Yankee Hill Road on the south. 27th Street is a four-lane arterial, north of South Street and south of Highway 2 to Pine Lake Road and a two-lane arterial from South Street to Highway 2.

- *U.S. Highway 77 (Homestead Expressway):* Four-lane expressway on the west side of Lincoln from I-80 south to Beatrice. North of Lincoln, also a four-lane expressway, Highway 77 provides access from I-80 to Fremont.

- *NW/SW 84th Street:* Paved, two-lane county road.

- *9th/10th Street:* One-way, north/south streets connecting Highway 2 to downtown Lincoln. These streets are utilized to access downtown and also connect to I-180 north of the downtown area.

- *14th Street (north of Superior Street and south of Highway 2 to Old Cheney Road):* 14th Street is a two-lane City/County roadway north of Superior Street and a four-lane arterial south of Highway 2 to Warlick Boulevard.

- *NW 48th Street:* Two-lane roadway connecting West "O" Street (U.S. Highway 6) and U.S. Highway 34 (Purple Heart Highway). NW 48th Street provides access to Air Park.

Figure 1: Priority Corridors

East-West Corridors:

- *I-80:* Four-lane, Interstate Highway along the north side of the City.

- *South Beltway:* Proposed beltway south of Lincoln between Highway 77, Highway 2 and the East Beltway. The proposed alignment is ½ mile south of Saltillo Road.

- *Superior/Havelock:* Northernmost east/west arterial street. It contains four lanes from 1st Street to Touzalin Avenue and two lanes east of Touzalin Avenue.

- *Cornhusker Highway (US Highway 6):* Mostly a four-lane arterial, through the City, with additional through lanes in the vicinity of 27th Street. It provides access west to Lincoln Municipal Airport and east to Omaha.

- *"O" Street:* The main east/west arterial through the City. "O" Street (also U.S. Highway 34 from 10th Street east through 84th Street to Eagle and beyond) is a four-lane arterial. Construction to widen from four to six lanes (52nd St. – Wedgewood Dr.) is scheduled to begin in 2002.

- *U.S. Highway 34 (Purple Heart Highway):* Four-lane expressway from I-80 to NW 31st Street and a two-lane highway west, providing access to Seward, Nebraska.

- *Normal Boulevard/Capital Parkway:* Four-lane arterial west of 56th Street providing access to downtown Lincoln. "K" and "L" Streets connect Capitol Parkway to Capitol Parkway West and Capitol Parkway West connects downtown Lincoln to Homestead Expressway.

- *Nebraska Highway 2:* Four-lane highway/arterial providing the major link between I-80 and I-29, near Nebraska City. Highway 2 is also a major truck route.

- *Old Cheney Road:* Four-lane arterial between Warlick Boulevard and Highway 2. Two-lane roadway providing connection to Highway 77 and also, two lanes east of Highway 2.

- *Van Dorn Street:* Four-lane arterial connecting 9th/10th Street (Hwy 2) to Highway 77, two-lane roadway west of Homestead Expressway

- Saltillo Road: Two-lane, paved County road.

- Denton Road: Paved, two-lane County road.

3.0 CITY OF LINCOLN ITS COMMUNICATION NETWORK

In the previous phase of this project, existing, short- (0-5 years) and long-term (6+ years) communication networks were discussed. In the following section, an update to the communication network for ITS is presented. This update is based on the growth projections for the City of Lincoln and the priority corridors that were identified in **Section 2.0**. The following analysis provides a preliminary communication plan for the implementation of ITS in the City of Lincoln. It should be noted that these plans are a "work in progress". This plan has been designed to not only meet the City's current needs but also to provide the flexibility to amend it in the future. In order to ensure this flexibility, the communication network has been designed for the short- and long-term time periods only. It is recommended that this plan should be modified and the long-term plan be divided into two possible plans (medium- and long-term) once the City of Lincoln nears the completion of the short-term ITS communication plan. This allows for revisions to the plan based not only on growth changes in the City but also technology improvements to the communication industry.

3.1 Existing Signal Interconnect

The City of Lincoln's Public Works and Utilities department primarily uses two types of media (twisted-pair and fiber optic), both of which are City-owned, for communication to signalized intersections. Twisted pair copper cable makes up the majority of the communication infrastructure for communication to the signalized intersections along the major and minor arterials. The City has a combination of 50, 25, 18, 12, and 6 pair cable installed underground and overhead. The Department of Public Works and Utilities also utilizes fiber optics infrastructure. **Table 1** presents the type and length of media and the location (overhead or underground) of installations. **Figure 2** presents the updated April 2001 existing communication system. In addition to the traffic control center, currently located at 531 Westgate Boulevard, the City's Public Works and Utilities Department presently has two communication hubs located at the intersections of 17th Street/"K" Street and 16th Street/"Q" Street.

3.2 Short-Term ITS Communication Needs

The focus of the short-term scenario will be on existing assets, expansion of the existing features and the introduction of foundations for application of ITS technologies during the long-term scenario. Some of these include gap closures of the existing twisted pair and fiber optic network and implementation of the initial stages of the long-term communication network. Due to the city's growth and the increase in size of communication infrastructure, it was necessary to update the communication needs analysis. **Figure 3** presents an updated preliminary short-term communication network. In addition to the existing two hubs, five new hubs have been identified for the short-term scenario. It should be noted that these hub locations are approximate locations. Exact locations should be identified during the final design process. The proposed hubs are located at:

- Traffic Management Center (TMC) at 531 Westgate Boulevard (increase in capacity of the centers capabilities)
- 27th Street at Cornhusker Highway
- 27th Street at Highway 2
- "O" Street at 84th Street
- 10th Street at "Q" Street

3.3 Long-Term ITS Communication Needs

The conceptual layout of the City of Lincoln's long term communication network (6+ years) is envisioned to include trunk communication, based on a ring topology, and several communication hubs located in the field. The trunk communications system may consist of a combination of multiple agency-owned twisted pair and fiber optic cable. Similar to the short-term communication scenario, the long-term analysis was also updated due to the City's increased existing communication infrastructure. **Figure 4** presents the preliminary proposed long-term communication network.

The network has been designed to accommodate future expansion of the system. The design of the system allows for redundancy within the network with a series of tail circuits connecting field elements to each hub. In addition to the two existing hubs and the hub locations identified for the short-term scenario, the following four hub locations have been identified for the long-term scenario, bringing the total number of hubs to 11.

- 84th Street at Havelock Avenue
- 84th Street at Highway 2
- NW 40th Street and Highway 34
- Van Dorn Street at SW 84th Street

Table 1
Existing City of Lincoln Signal Interconnect System

Communication Media	Location	Length (ft)
50-pair cable	Underground	16,450
	Overhead	0
Sub-total		*16,450*
25-pair cable	Underground	22,900
	Overhead	15,600
Sub-total		*38,500*
18-pair cable	Underground	4,700
	Overhead	1,350
Sub-total		*6,050*
12-pair cable	Underground	3,400
	Overhead	6,500
Sub-total		*9,900*
6-pair cable	Underground	194,700
	Overhead	105,000
Sub-total		*299,700*
Fiber Optic	Underground	74,000
Sub-total		*74,000*
Total		**444,600**

Source: City of Lincoln Department of Public Works and Utilities

Figure 2: Existing Communication System

Figure 3: Short-Term Communication Network

Figure 4: Long Term Communication Network

4.0 ITS COMMUNICATION SUPPORT AND COORDINATION

During this phase of the project, the focus has been on identification of the communication requirements as well as discussions with private communication providers. The following section presents a preliminary, high-level communication analysis that was conducted based on the identified priority corridors presented in **Section 2.0** of this report. A summary of discussions with various local communication providers has also been included. In addition, an evaluation process used to select the appropriate method, techniques and approach to the deployment of the overall City of Lincoln ITS communication system is presented.

4.1 High Level Communication Analysis

Prior to developing a proposed communication plan, it is first necessary to identify the amount of information that will be transmitted between potential ITS field elements and a central location or TMC. The deployment of ITS elements is assumed to take place in phases (short- and long-term), thus the infrastructure to communicate with these field devices can also be spread out over two phases. When the communications network is deployed, it must be capable of handling the transmission of information in the short term, as well as the long term.

The capability to handle information for the life of the communication network dictates that communication media or links nearest the head-end (TMC) be sized according to the future requirements, even though they will only be utilizing a portion of the ultimate bandwidth capabilities in the short term. The bandwidth requirements are reduced as one increases the distance from the head-end location to field devices deployed on the periphery of the project area.

For this analysis, it is envisioned that the current location of the Public Works and Utilities Department, Engineering Services Division, located at 531 Westgate Boulevard will be the head-end location for communication with the field elements deployed along the arterial system.

The ultimate communication network needs to accommodate the following traffic signal control and management capabilities. It is assumed that the City of Lincoln would have a computerized TMC with full access to the following field equipment deployed along arterial roadways:

- *Signal controllers* - Signal controllers provide the basic operating system for each signalized intersection.

- *Closed circuit television (CCTV)* - Surveillance CCTV cameras are recommended for installation at key intersections in the City. Pan, tilt and zoom (PTZ) control will allow system operators to focus in and see traffic movement and provide incident verification. If an incident has been observed via the CCTV, the operators will then be able to provide manual intervention and if required, dispatch equipment to assist in incident removal in a coordinated fashion.

- *Dynamic message sign (DMS)* - DMS offers a valuable technique to provide motorists with real-time traffic information and, if desired, alternate route selection advisories in advance of key decision points along the interstate and along primary corridors. DMS can provide timely, accurate and reliable information to motorists when installed at critical locations. This can be achieved without the need for special, in-vehicle equipment.

- *Highway advisory radio (HAR)* - HAR is a proven and available method for dissemination of traveler information. HAR service can be used to broadcast recorded messages concerning activities such as construction work and road closures. In addition, HAR can be used to advise truckers and other interstate travelers of roadway conditions.

The largest group of communication needs is between the TMC and each field hub. Following is a brief description discussing the assumptions made for each field element equipment category. It should be noted that for the long-term scenario, it was assumed that the ITS elements will be installed east to the East Beltway (six miles east of 84th Street) and south to the South Beltway (four miles south of Pine Lake Road).

CCTV

- Communication from each CCTV camera site to hub is envisioned to be via one dedicated fiber strand per deployed camera. Control and video can be transmitted either analog (6 MHZ) or digital (45 Mbps-uncompressed). For added system flexibility, two strands of fiber could be utilized.

- At a hub, video signals could be multiplexed (sending multiple signals or streams of information on a carrier at the same time in the form of a single, complex signal and then recovering the separate signals at the receiving end) in groups and transmitted to the TMC.
  - The video signal can also be digitized and compressed at the hub to either 1.54 Mbps or 3.088 Mbps using CODECs (encoder/decoders).

- Compression equipment could also be used at each individual camera site. However, dedicated strands would still be required to each camera.
  - If 1.5 Mbps optical transceivers are used at the camera site, then once video/control is received at the hub, it will then be multiplexed (in groups of 10, for example) and transmitted to the TMC. No further compression is required at the hub.

- To provide a seamless surveillance system, it was assumed that CCTV cameras would be installed every mile along major arterials.

DMS (Dynamic Message Sign)

- DMS (NTCIP-based) utilizes a controller similar to signalized intersections, thus it is assumed that it will require 19,200 baud for data communications.
- DMS are also known as variable message signs (VMS) or changeable message signs (CMS).

Signalized Intersections

- Signalized intersections also include pedestrian and school crossings, intersection flashers and fire station signals.
- NTCIP-based traffic controller will require 19,200 baud for data communication.

HAR (Highway Advisory Radio)

- Typically a standard voice circuit is the minimum communication needed to record/edit messages, and to access pre-assigned Dual-Tone Multi Frequency (DTMF) key combinations to control transmitter functions. A standard 19,200 bps voice bandwidth is assumed.

Based upon the assumptions described above, **Table 2** provides the projected bandwidth and number of field devices needed for the City of Lincoln communications system.

Based on the table below, it is assumed that approximately 180 Mbps for the short term and 590 Mbps for the built-out (short- and long-term combined) of data/video will be transmitted between the TMC and field hubs once the complete system is in place.

Table 2
Bandwidth Requirement for the City of Lincoln ITS

Device	Deployment Phase	Communication Requirement (kbps)	Number of Units [1]	Total Data Load (Kbps)
CCTV	Short	3,088	57	176,016
	Long	3,088	130	401,440
Total			187	577,456
DMS	Short	19.2	14	269
	Long	19.2	20	326
Total			34	595
Signalized Intersections	Short	19.2	179	3,437
	Long	19.2	331	6,355
Total			510	9,792
HAR	Short	19.2	2	38
	Long	19.2	4	76
Total			6	115
Estimated Short Term Bandwidth				179,760
Estimated Built-Out Bandwidth (Short and Long-Term Combined)				587,958

(1) Number of units includes an approximate 10 percent contingency for CCTV, DMS and HAR. It also includes an approximate 20 percent contingency for signalized intersections

4.2 Communication Media

The City of Lincoln traffic management system will require the transmission of both data and video signals. Data transmission consists of relatively low speed, low volume control and monitoring of data between traffic signal controllers, DMS display and camera control, and the central computers at the TMC. On the other hand, video signal transmission requires a much greater communication capacity. These data communication requirements can be met using a variety of communication media. The following is a brief discussion on the different media that can be used for the City of Lincoln communication network. **Table 3** presents a comparison of the various ITS communication media available. **Figures 5** and **6** present the proposed short and long-term ITS traffic operation communication system maps, respectively. The figures present the number of ITS elements per priority corridor and corresponding estimated bandwidth requirements per corridor and hub. **Figure 7** presents the build-out hub allocation information for each hub.

- **Fiber Optics**. Fiber optics technology transports information by sending light waves through the glass strands of a fiber optic cable. Therefore, in order to install a fiber optic network, a communications conduit and fiber optic cable infrastructure must be available.

  If not owned by the area agencies, it may be possible to lease fiber optic cable from private communications providers. The analysis included in **Section 4.6** of this report explores such possibilities.

  Fiber optic cable requires the use of fiber optic equipment to convert the digitized data signal into a fiber optic analog signal. This equipment ranges in price depending on the amount of bandwidth required and number of channels to be used. The fiber optic cable could be terminated and connected to the fiber optic communications equipment at each location, i.e., controller cabinet, TMC, or communications room.

- **Twisted Pair**. Twisted pair cabling can be used to support any existing communications technology. However, as in the case of fiber optics, a communications conduit and copper cable infrastructure must be available. These include dedicated circuits capable of transporting data at rates of 300 bps to full T1, equivalent to 1.544 Mbps.

  Twisted pair cabling would be terminated and connected to communications equipment at each location (i.e., controller cabinet, TMC, or communications room).

- **Spread Spectrum Radio**. Spread spectrum radio (SSR) is one of the newest of the wireless technologies being applied in traffic control. It is a non-licensed technology that uses radio broadcast power of less than 1 watt. The functional operation of a SSR is identical to that of a modem.

  Unlike single channel radio, SSR is sensitive to line-of-sight antenna propagation. Although not as critical as that of satellite or microwave (narrow beams), antenna alignment is an issue. This is generally overcome by the use of directional antennas.

- **Satellite**. Very Small Aperture Terminal (VSAT) is the industry standard for satellite technology. VSAT technology is unique in that it requires line-of-sight antenna propagation from the earth station to the geosynchronous satellite in stationary earth orbit. Oftentimes this presents problems in placement of equipment.

  Satellite transponder channels (air time) would have to be leased from one of the existing satellite companies or a leasing company. VSAT does not require an FCC license.

  VSAT would not require installation of a communications conduit and cable infrastructure. VSAT transmitters/receivers would be installed at each location (e.g., controller cabinet, TMC, or communications room). Antennas would be installed on roofs, towers, or signal poles.

Table 3: Comparison of Various ITS Communication Media

Figure 5: Short-Term ITS Traffic Operation Comm. System Map

Figure 6: Long-Term ITS traffic operation comm. System map

Figure 7: Build-out hub allocation figure

- **Microwave**. Microwave signals are transported identical to satellite signals with one exception. The signals are transmitted from antenna to antenna versus antenna to satellite to antenna. Microwave technology requires line-of-sight antenna propagation between antennas, which can present problems in the placement of equipment.

  Microwave equipment is rated as either licensed or non-licensed depending on transmitter power and bandwidth. If FCC license is difficult to obtain due to the high usage of microwave in the area, it may be possible to "piggy-back" onto a number of different existing microwave users (i.e. law enforcement) if spare bandwidth is available.

  Microwave transmitters/receivers would be installed at each location (e.g., controller cabinet, TMC, or communications room). Antennas would be installed on roofs, towers, or signal poles.

  Microwave would not require installation of a communications conduit and cable infrastructure.

4.3 Data Transmission Technologies and Standards

Some of the data transmission technologies and standards that can be used in the City of Lincoln communication system are:

- **T1 Technology**. T1 technology is the oldest form of high speed digital data service, providing data rates from the basic T1 (1.5544 Mbps) to T3 (44.736 Mbps) using twisted pair cable for lower rates and fiber optic cable for higher rates. T1 technology uses individual digital service channels of 64 Kbps, each which can easily be multiplexed and demultiplexed. This technology is limited to a point-to-point or point-to-multipoint topology only.

- **Integrated Services Digital Network (ISDN)**. ISDN is a set of standards for digital transmission over ordinary telephone copper wire as well as over other media. ISDN is built on T1 technology, 1.544 Mbps, with one advantage and one disadvantage. The advantage of ISDN is that it uses a circuit switched technique, and therefore is not limited to any certain topology. The disadvantage is it can only be leased at 128 Kbps or 1.5444 Mbps data rates. All nodes subscribing to ISDN services have a unique network address which is required for call set-up. With ISDN, each regional corridor and agency would require a single connection to the network. Data can then be transferred by "dialing" a system. Once the information is received, the call can be terminated. Alternatively, the connection can be maintained for as long as it is required, however, this prevents access by others.

  ISDN was developed for use as a "bandwidth on demand" network with a pricing incentive for infrequent use. If a network requires continuous communication, a dedicated circuit is preferable. The use of ISDN for dedicated services has a higher cost than dedicated T1 service.

- **Frame Relay**. Frame relay is a technology that transports data in frames, which is more efficient than T1 technology. Frame relay is available at data rates of 56 Kbps, 128 Kbps, 256 Kbps, 384 Kbps and 1.5544 Mbps. Frame relay provides permanent virtual circuits between network nodes, which can be configured as either point-to-point or point-to-multi-point. There is no incremental cost for usage or distance, which makes frame relay a cost-effective, attractive alternative to T1 networking.

4.4 Standards

Communication standards define the processes, formats, and electrical and physical requirements for the interface of the network elements. In the absence of such standards, users would not be able to create, expand, or interconnect their systems and networks. For this reason, the International Standards Organization (ISO) has developed a model as the basis for describing standards, known as the Open System Interconnection (OSI). The OSI model is made up of seven layers. Each layer of the transmitting device must be compatible with its counterpart in the receiving device. Many existing standards are being reformatted for compatibility with this model and most new standards are being developed in terms of its layers.

Some of the most appropriate or applicable standards that could be used for the City of Lincoln Communication System are:

- **Fiber Distributed Data Interface *(FDDI)* Standard**. This standard, which is developed by the American National Standard Institute (ANSI), specifies a packet-switched LAN-to-LAN backbone that transmits data at high rates over a variety of multi-modal optical fibers. It allows development of metropolitan area-sized networks accommodating 100 Mbps data rates across the backbone. The FDDI standard is ideal for a token ring network with dual counter-rotating fiber rings that will stretch over tens of miles.

- **Synchronous Optical Network *(SONET)***. Synchronous Optical Network is built on a standard base rate called OC-1 (Optical Carrier 1), which represents a transmission rate of 51.84 Mbps over optical facilities. The electrical equivalent of OC-1 is STS-1 (Synchronous Transmission System 1). The SONET hierarchy in high speed, optical transmission builds in multiples of OC-1, up to and including OC-48, with an equivalent bandwidth of 2.48832 Gbps over an optical carrier. The extraordinarily large bandwidth and simple multiplexing method of SONET are outstanding benefits that allow a multitude of possible opportunities for applications supported by public and private networks.

- **Asynchronous Transfer Mode *(ATM)***. ATM is an emerging communication technology that offers the bandwidth and flexibility for new applications on backbone networking. ATM technology represents the adaptation of older packet switching technology to modern networking conditions. The new switching technology is based on "cell relay" and provides higher speed to support voice, data and video services. The call replaces the packet as the network information unit and the short cell length combined with high transmission rates provide high bandwidth flexibility. ATM is intended to be:

    - fairly simple and protocol independent
    - fast
    - usable with new protocols

  ATM provides a signal interface for all communications, which provides capability for transmitting voice, data and video all together.

  In the same tradition of other recent protocols, ATM assumes that the communications lines are fairly clean, and attempts neither error correction nor detection. One might compare frame relay to ATM by noting that frame relay spans about one and half layers of OSI, and ATM only covers the first layer. X.25 (the initial layer name within ATM) handles packet retransmission and error checking, frame relay handles just error checking, and ATM handles neither. ATM does not check accuracy, but it does have the capability to retransmit, and it provides a fast, simple interface to a network.

The ATM Forum (standards committee) specifies a SONET STSC (155 Mbps) interface for both public and private interfaces to synchronous networks.

4.5 Other Communication Infrastructure

The following section presents some of the other communication providers in the City of Lincoln. **Appendix A** provides minutes from meetings with some of these communication providers.

1. ***State of Nebraska, Division of Communication:*** The Division of Communications does not wish to own or operate any type of communications. They are responsible for administering and bringing together contracts between providers and end users . Currently, the Division of Communication is in the process of aggregating communication bandwidth among various providers. The goal is to develop "Postalizing" of pricing that would result in potential price reductions of 20 - 40%. They have collected an extensive existing communication inventory throughout the State for the TINA (Telecommunication Inventory Needs Assessment) Project.

2. ***Lincoln Electric System (LES):*** LES is a public utility company owned by the City of Lincoln. Currently, LES has an OC-3 SONET ring (overhead on LES owned high voltage transmission lines) around the City. The fiber ring is strictly reserved for LES use only. LES's filing to become a contract carrier in the City of Lincoln was denied on January 9, 2001.

3. ***MCI:*** Currently, MCI only provides long distance (city-to-city or state-to-state) service and has no plans of providing service within the City of Lincoln in the next five years.

4. ***Sprint:*** Currently Sprint provides only wireless service in the City of Lincoln.

5. ***Galaxy Communication:*** Currently, Galaxy Communication does not have an extensive fiber optic system in the City of Lincoln. However, Galaxy will build to suit City of Lincoln's communication needs.

6. ***Time Warner:*** Time Warner is the primary provider of cable television service throughout the City of Lincoln. Many CATV systems are currently in the process of converting from analog-based coax cable systems to digital fiber optic cable plants with excess capacity available.

7. ***Alltel Communications:*** Alltel has an extensive single mode fiber optic SONET ring in the Lincoln area and downtown along major corridors. Alltel Communication also has an existing OC-192 between the Cities of Lincoln and Omaha.

8. ***Dark Fiber Solutions:*** Currently, Dark Fiber Solutions does not have an extensive fiber optic system in the City of Lincoln; it does, however, provide some service to the Department of Education and community colleges in Lincoln. Dark Fiber Solutions is willing to build to suit City of Lincoln's communication needs.

9. ***Quantum Electric:*** Currently, Quantum Electric does not have a fiber optic system in the City of Lincoln. However, they will build to suit the City of Lincoln's communication needs.

Numerous attempts were made to contact ***Level 3 Communications*** and ***People's Utilicorp*** in regards to their communication infrastructure within the City of Lincoln. However, these attempts were unsuccessful.

4.6 ITS Communication Alternative Analysis

For the purposes of this analysis, it has been assumed that fiber optic cable will be the main type of communications media used for deployment throughout the City of Lincoln. City of Lincoln Public Works and Utilities Department has a large and encompassing existing twisted pair network throughout the City. In addition, the City has fiber optics installed in some areas. It is envisioned that this network of twisted pair and fiber optics will remain in place and will be usable for a number of years to come. The future fiber optic cable will be seen as a supplement media in this area. For example, deployed CCTV cameras will send video back to the City's TMC via newly installed fiber optic cable and the signalized intersections will continue to use the existing twisted pair. In some instances, where a higher bandwidth is needed for data transmission, the link will then be migrated to fiber optic cable. If no twisted pair is in place, fiber optic cable will be used as the default for new communication media to connect the signalized intersections to the TMC. If there are no planned ITS elements (requiring a higher bandwidth for transmission) along a particular corridor, then twisted pair cable could remain as the media of choice. Although fiber optic cable is well suited to carry large data volumes, it is also capable to act "just like" twisted pair cable and transmit low speed data efficiently and effectively. Fiber optic cable can be used to connect multiple signal controllers on a single fiber strand (commonly known as "daisy chaining").

Two other solutions to the interconnection of signal controllers would be to install twisted pair cable in the same conduit as the fiber optic cable, or install a hybrid cable which has both twisted pair cable and fiber optic strands within one cable sheath. However, the installation of a second twisted pair cable will pose significant cost increases and may prove harmful to the fiber optic cable during installation (cable damage during installation). In the case of using a hybrid cable, it is typically a "custom" order and requires additional lead-time during ordering, and added cost per linear foot (on the order of double or triple the regular cable cost).

Using the information provided by the private communication providers, some benefit could be achieved through the use of leased services as they relate to low bandwidth requirements. However, when the City wishes to provide a connection between the field hubs and the TMC, it may be more cost-effective to install dedicated city-owned communication links.

For example, if the city wishes to connect the proposed hub at the intersection of 27th Street and Cornhusker Highway to the TMC, the design and construction cost would be approximately $450,000-$550,000. This would include the design and installation of a City-owned single-mode fiber optic cable containing 48 strands of fiber for approximately three miles in length. This would provide sufficient bandwidth to transmit the estimated 48 Mbps data stream (includes 15 CCTV, 33 controllers, and 5 DMS). It would also provide some flexibility should the need to increase the bandwidth arise in the future. This could be accomplished through the changeout of end equipment to raise the transmission rate.

As with all communication infrastructure, there would also be maintenance costs associated with the installation. These costs are on the order of 3 to 5% of the installation cost per year or approximately $12,000 to $20,000. This would include accidental cuts of the fiber as well as general hub maintenance (ensuring all connections are solid). The life cycle of installed fiber optic is considered to be between 15-20 years depending upon its installed location, and any damage that may have occurred over the years of service.

Comparatively, should the City desire to lease a communications link between the TMC and the proposed hub at the intersection of 27th Street and Cornhusker Highway for the same 15-year period, the cost increases dramatically. Using the costs illustrated in **Table 4**, the City would need to lease the equivalent of 32 DS/0 circuits at a price of $452/month for 60 months, which is approximately $867,840 (32 circuits x $452 per circuit x 60 months) plus the one-time nonrecurring cost of $55,040 ($1,720 x 32 circuits) for a total of $922,880. This includes only the cost to lease the data link and does not include the compression equipment at both the TMC and at the hub for the transmission of video across the 1.54 Mbps link. At the end of the five-year period, the City would either need to renegotiate their lease with the same or different provider or begin installation of their own communication infrastructure.

Table 4
Private Provider Cost Comparison
T1 (DS/1) Digital Data Service

Item	**Month-to-Month Lease**	**36-Month Lease**	**60 Month Lease**
Nonrecurring Cost (Initial Cost) [1]	$1,720	$1,720	$1,720
Monthly Recurring Cost [2]	$645	$548	$452
Total Cost	$1,293,440	$1,107,200	$922,880

Notes:

1 *Nonrecurring Cost:* This is an one-time setup fee that the communication company will charge the City of Lincoln Public Works Department.

2 *Recurring Cost:* This is generally a monthly fee accessed based on the amount of bandwidth that is leased from the communication provider. The distance between the two end points (i.e. field hub to TMC) also plays a role in the overall cost of the service. Based on the duration of the leasing contract (month-to-month, 36 month, 60 month, etc), the recurring cost would vary.

As evident from this example, the installation of City-owned communication infrastructure makes fiscal sense from both a cost and flexibility standpoint as well as an overall life cycle cost perspective. However, it should be noted that at some point, the margin of difference between leasing versus owned becomes smaller, although the element of "what to do after the lease expires" remains. The point in which the margin of difference between leasing versus owned becomes small is dependent on many variables including distance, lease terms, etc.

If the City decides to install its own communication infrastructure, it would be cost-effective to attempt to develop a public/private or public/public partnership to share the cost of the installation of infrastructure. This type of partnership would share the cost of installing conduit and/or fiber optic cable in a common (shared ownership) trench. This reduces the initial cost of installation as well as reducing the number of pavement cuts (one trench versus two). Once the City identifies a specific corridor they plan to install communication infrastructure, an internal marketing plan should be developed whereby other city agencies are contacted to see if a shared need is present. For example, the Lincoln Public School District may wish to bring another campus online to their central system. This would allow the cost of the trench to be shared, which is the most expensive part of installation. Separate and dedicated access to the conduit could also be achieved through dual pull boxes or communication vaults.

Should no City agencies share the same need along a particular corridor as the Public Works and Utilities Department, then the Department could release a brief Request For Information (RFI) to private providers stating the intent, purpose, and the project location (begin and end points). Several of the private providers we spoke to would be interested in a "build-to-suit" scenario. This would allow them to share the initial installation costs, and build spare capacity to their own system to lease or sell at a later date.

5.0 ITS USER NEEDS

Prior to identification of the appropriate ITS User Services for the City of Lincoln, it is important to clearly understand the transportation needs and have an idea of the prioritization of those needs. The following section will summarize the ITS goals and objectives that were identified during this project. These goals and objectives are then mapped to ITS user services.

5.1 ITS Goals and Objectives

In order to bring focus to the ITS planning process for the City of Lincoln, it is imperative to grasp the goals and objectives of the effort. It is critical that the ITS designed and ultimately deployed in the City of Lincoln pursue the identified goals and objectives to maximize the effective deployment of ITS which addresses the needs of transportation users and managers. Through meetings with the various agencies on October 14, 1998, December 1, 2000 and February 27, 2001, a set of goals and objectives were identified. **Table 5** provides a list of these items. It should be noted that even though some of the items listed below do not have a direct relationship with ITS, they are still considered important factors in an efficient transportation network and are worth mentioning. **Appendix B** presents a list of the attendees of these three sessions.

5.2 ITS User Services Identification Process

This section addresses the concept of ITS "User Services", their role in the City of Lincoln's ITS plan and how they will be identified. "User Services" are the first in a series of concepts from the "National ITS Architecture" that will be used in the development of the plan. The National ITS Architecture is a series of documents prepared by the United States Department of Transportation intended to provide a common framework for planning, defining, and integrating ITS. Such a common framework promotes consistency and compatibility in ITS deployed by different organizations.

One of the most compelling reasons to follow the National ITS Architecture is that the Transportation Equity Act for the 21st Century (TEA-21) requires that any ITS project receiving funds from the highway trust fund "conform" to the National ITS Architecture and applicable standards. A final federal rule regarding ITS Architecture and Standards published in the Federal Register in January 2001 proposes to implement and significantly amplify that requirement. Other benefits of using the National ITS Architecture include: potential time savings (much of the work has been done and can be easily adapted to local contexts); minimization of the risk of omitting important components or connections or missing opportunities; facilitation of future ITS expansions; allow participation in the national ITS equipment vendor market emerging around the National ITS Architecture and associated ITS standards (i.e., benefit from more competitive pricing of non-proprietary equipment).

Table 5
Identified ITS Goals and Objectives
"Work in Progress"

• Improve safety
• Improve mobility
• Provide pre-trip traveler information
• Identify community assets
• Provide education and awareness of ITS elements
• Develop partnerships (Public/Private)
• Preserve roadway structural integrity and weigh-in-motion projects
• Move traffic safely and efficiently
• Consider regional transportation needs (in & out of City)
• Identify an acceptable level of service (i.e., congestion level)
• Provide information on construction zones
• Develop coordination and cooperation between entities involved in construction
• Develop a system that is easy to maintain and operate
• Develop coordination between City & County on all projects.
• Consideration of railroad crossings
• Allow public to monitor progress of ITS improvements
• Encourage public participation
• Incorporate system integration and consistency, architecture, information sharing
• Create public awareness on congestion and transportation
• Provide education to the public and other entities and obtain their expectations
• Ensure the avoidance of duplication of efforts
• Develop cohesive planning
• Develop a bike-friendly environment
• Develop a productive transportation demand management program
• Develop options for the use of other modes of transportation
• Maximize existing assets
• Integrate public transportation
• Preserve neighborhoods
• Maximum communication infrastructure (maximize public investment) / Sharing of resources between various city agencies
• Develop pedestrian friendly sidewalks/walkways. Pedestrian overpasses
• Preserve historic landmarks
• Minimize travel time/reduce delay
• Develop parking facility needs (downtown and area-wide). Inform the user.
• Reflect the long-range transportation plan and future land use conditions.
• Integrate the use of fleet management (AVL and AVI)
• Improve air quality
• Develop an incident management program

5.2.1 National ITS Architecture User Services

User Services are services that can be provided to transportation system users and operators to address their needs, for example, "Pre-Trip Traveler Information". The user service concept was developed in the National ITS Program Plan (1995), and later became one of the fundamental concepts around which the National ITS Architecture was developed. The initial version of the National ITS Program Plan identified 29 User Services, organized into six categories or "bundles". Since that time, two additional services have been added to the list for a total of 31 User Services. **Table 6** presents the current list of 31 national ITS User Services. The services are described in the sections that follow, organized by bundle.

Table 6
User Service Bundles and User Services

User Services Bundle	User Services
Travel and Traffic Management	Pre-trip Travel Information En-Route Driver Information Route Guidance Ride Matching and Reservation Traveler Services Information Traffic Control Incident Management Travel Demand Management Emissions Testing and Mitigation Highway-Rail Intersection
Public Transportation Management	Public Transportation Management En-Route Transit Information Personalized Public Transit Public Travel Security
Electronic Payment	Electronic Payment Services
Commercial Vehicle Operations	Commercial Vehicle Electronic Clearance Automated Roadside Safety Inspection On-board Safety Monitoring Commercial Vehicle Administrative Processes Hazardous Materials Incident Response Commercial Fleet Management
Emergency Management	Emergency Notification and Personal Security Emergency Vehicle Management
Advanced Vehicle Safety Systems	Longitudinal Collision Avoidance Lateral Collision Avoidance Intersection Collision Avoidance Vision Enhancement for Crash Avoidance Safety Readiness Pre-Crash Restraint Deployment Automated Vehicle Operation
Information Management	Archived Data Function

From National ITS Architecture, Version 3.0; USDOT, 1999

5.2.2 National ITS Architecture "Emerging" User Services

In addition to the 31 nationally defined ITS User Services, another source of potential User Services was evaluated. The status of several potential, or emerging, User Services were researched. As the

National ITS Architecture evolves, potential additions to the list of national ITS User Services are continuously being considered by the USDOT in conjunction with ITS America. These modifications are based on experiences with ITS across the country and the world. Currently, there are six potential new national ITS User Services that are being evaluated, as described in **Table 7, and this trend of adding user services is sure to continue**. The specificity of the summaries in **Table 7** varies, reflecting the relative level of development and consideration received to date. The most fully developed emerging user service, Maintenance and Construction Operations, is being recommended by the USDOT for inclusion in the next version of the National ITS Architecture (4.0), expected to be released in late 2001.

Table 7
"Emerging" User Services

User Service Name	Description
Maintenance and Construction Operations (MCO)	Describes the need for integrating key activities to insure that roadways, associated infrastructure, and available resources are managed in an optimal manner. Key activities included in this user service include monitoring, operating, maintaining, improving, and managing both the physical condition of and equipment on the roadway. The focus for this user service would be on the following six functional areas: • Maintenance Vehicle Fleet Management – monitor/track vehicle locations • Infrastructure Management – automate the inventory process for both ITS and non-ITS roadside infrastructure • Roadway Management – detect road/weather conditions & optimize maintenance crew operations • Work Zone Management and Safety – manage work zone activities & communicate with travelers • Roadway Maintenance Conditions and Work Plans Dissemination – provide O&M information to agency staff and travelers • MCO Management – Tracking Out-sourced Contracting – monitor/track private sector O&M activity performance.
Disaster Response and Management (DRM)	Addresses the coordination and management of responses to large-scale natural and man-made disaster situations. This would include a wide range of disaster types, such as floods, hurricanes, earthquakes, tornadoes, fires, avalanches, chemical spills, nuclear incidents, etc. These are events that cause significant disruption to community services, could cause significant loss of life and/or property, create major disruption in transportation services, and/or require evacuation of large numbers of people. This user service does not repeat the same functionality already included in other User Services such as coordination between Traffic Management and Emergency Management for routine events. Instead, the DRM user service expands it to effectively support the scale of resource coordination required to respond to disasters. The functional areas included in this user service are: • Traveler Disaster Information and Notification • Evacuation Management • Monitoring status of routes, services, facilities • Transportation Agency Response Coordination with Other Emergency Services • Civil Defense/National Guard. • Red Cross

User Service Name	Description
	• Public Safety
Safe Driving Enforcement (SDE)	Supports various mechanisms (e.g., systems, processes, procedures, etc.) to enforce roadway controls and policies in situations where violations pose particular safety risks to violators and/or other travelers. Generally, key SDE activities include monitoring roadway conditions and/or vehicle movements, comparing this collected data vs. "safe" operating parameters, providing information to the traveler regarding their current vehicle operations, and alerting the appropriate law enforcement agency when a violation occurs. The SDE user service may be considered applicable to both urban and rural environments. The SDE user service focuses on the following components: • Variable Speed Limit Management and Enforcement • Weather/Environmental Conditions-based • Roadway Geometry Based • Intersection Signal/Signage Enforcement • Highway-Rail Intersection Signal/Signage Enforcement.
Environmental/ Weather Information Management	Focuses on the development and dissemination of integrated weather and/or environmental products relevant to roadway transportation. The elements of this user service include: • Integrated Weather/Environmental Data Gathering • Weather • Road Surface Sensing • Pollution/Air Quality • Information Products Dissemination • To Agencies/Organizations • To Travelers • Weather Emergency Response.
Intermodal Freight Logistics	Intermodal is the movement of goods that involve more than one mode of transportation. Virtually all air, waterborne and non-bulk rail shipments are categorized as intermodal. Motor carrier movements are apt to be part of almost all intermodal movements. The key stakeholders involved in intermodal freight are shippers, ocean carriers, rail carriers, drayage companies and marine terminal operators. The functional areas of importance to the intermodal community are: • Freight In-Transit Monitoring • Container and freight shipment tracking • Container monitoring (temperature, shock, vibration) • Information management • Freight Terminal Management • Terminal vehicular traffic control • Security • Customs interface • Container pickup/drop-off acknowledgment.
Multi-Jurisdictional Emergency Management	The National ITS Program Plan includes only 2 User Services related to Emergency Management: Emergency Notification & Personal Security and Emergency Vehicle Management. These services may not fully address the needs related to Emergency Management as it relates to the transportation community and ITS technologies. One area in particular that could be

User Service Name	Description
	improved upon through a new user service is the coordination of emergency or incident management data between the various agencies in a region. During most emergency calls more than one agency must be involved in the response. For instance, police are needed to respond to a fire to be able to direct traffic around streets that the fire & rescue departments have closed.

Source: Unpublished materials provided by the Joint Program Office of the Federal Highway Administration, June 2000. All information is preliminary and may change.

5.3 Selection of User Services

The first step in the process to select the appropriate User Services is to develop a master list for analysis. A review of Lincoln's ITS goals and objectives as well as the potential User Services resulted in the incorporation of all User Services defined in **Section 5.2.1** except for the Advanced Vehicle Safety Systems bundles. The reason for the exclusion of the Advanced Vehicle Safety System bundle was that it mainly focuses on the automotive industry where the technology will be developed and installed by private entities versus public agencies. **Table 8** presents the list of ITS User Services that were considered for analysis.

Table 8
ITS Users Services Used for Analysis in Lincoln, Nebraska

User Services Bundle	User Services
Travel and Traffic Management	Pre-trip Travel Information En-Route Driver Information Route Guidance Ride Matching and Reservation Traveler Services Information Traffic Control Incident Management Travel Demand Management Emissions Testing and Mitigation Highway-Rail Intersection
Public Transportation Management	Public Transportation Management En-Route Transit Information Personalized Public Transit Public Travel Security
Electronic Payment	Electronic Payment Services
Commercial Vehicle Operations	Commercial Vehicle Electronic Clearance Automated Roadside Safety Inspection On-board Safety Monitoring Commercial Vehicle Administrative Processes Hazardous Materials Incident Response Commercial Fleet Management
Emergency Management	Emergency Notification and Personal Security Emergency Vehicle Management
Information Management	Archived Data Function

5.4 Mapping Transportation Goals and Objectives to Identified User Services

The second step in the process of selecting ITS User Services for application in the City of Lincoln consisted of "mapping" User Services to the ITS goals and objectives identified in **Section 5.1**. The mapping process consists of flagging the User Services that are needed to meet, in whole or in part, each goal and objective. **Table 9** illustrates the User Service mapping exercise.

In associating User Services with needs, only services that directly and substantially contribute to the goals and objectives have been identified.

5.5 Assessment to Add or Modify User Services

After mapping the identified transportation needs to the candidate User Services, the results were reviewed to determine if:

1. The selected services adequately address all of the goals and objectives and;
2. If the User Services should be modified or new services created.

As noted in **Section 5.3**, there are a number of reasons why some needs may not be fully addressed through ITS User Services. Some needs may not necessarily warrant ITS User Service creation or modification, and some needs cannot be entirely solved with ITS. For example, although the problem of "inadequate parking" can be in part addressed by providing travelers with convenient and accurate real-time information on parking availability, the problem cannot be fully resolved if in fact there is truly a significant shortage of parking. Typically, in order to illuminate the overall picture and to underscore the fact that ITS strategies are only part of the solution package, a needs identification process must consider all deficiencies, not just those that may have ITS solutions. Referring to **Table 9**, which includes needs such as "funding for transportation, including maintenance and road building", it is evident that the identified transportation needs include many such issues that transcend ITS.

Secondly, there are some needs that require an ITS related effort that is not, strictly speaking, an ITS User Service. For example, "traffic signal coordination across jurisdictions" includes two important facets. The first, the signal coordination itself, is certainly addressed through the "traffic control" User Service. However, the second, and arguably the more challenging facet relating to inter-jurisdictional coordination, may require substantial institutional efforts above and beyond the ITS technology.

Many of Lincoln's identified goals and objectives are ITS and transportation-system related and will be mapped to the National ITS Architecture process. Goals and objectives which are not directly or in-directly related (i.e. historic preservation, pedestrian friendly sidewalks, etc.) will remain within the document, as they are important goals for the community in general. It should be noted that mapping of goals and objectives to user services and following through to the creation of the regional ITS architecture does not lock the City of Lincoln to strict or stringent guidelines. This process should be interpreted as a facilitation or pathway document to provide overall guidance and direction. In other words, it is a "linking document" and should be updated and modified to meet the needs of the City.

Table 9: User Service Mapping Exercise

6.0 RECOMMENDATIONS AND CONCLUSIONS

The following section presents a summary of the work completed as part of this phase of the project. In addition, the steps necessary, in the next phase of this project, to make ITS a reality in the City of Lincoln are discussed.

6.1 ITS Communication System

During this phase of the project, a high-level communication requirement analysis was conducted in order to look into possible partnerships for the implementation of a communication system that meets the City of Lincoln's ITS user needs. In order to reduce the cost of installing conduit and/or fiber optic cable, it is recommended that the City should attempt to develop a partnership in the following two ways:

- Public/public partnership: Once the City identifies a specific corridor where they plan to install communication infrastructure, an internal marketing plan should be developed whereby other City agencies are contacted to see if a shared need is present. This would allow the cost of the trench to be shared, which is the most expensive part of installation. Separate and dedicated access to the conduit could also be achieved through dual pull boxes or communication vaults.

- Public/private partnership: If no City agency shares the same needs along a particular corridor, then the City should release a brief Request For Information (RFI) stating the intended purpose, and the project location (begin and end points). This would allow private providers to share the initial installation costs, and build in spare capacity to their own systems.

The next step in the development of an ITS communication system for the City of Lincoln would be to assign ITS elements to each priority corridor based on the user needs. These elements would include video surveillance, dynamic message signs, vehicle detection, and advanced traffic control system elements. Based on the distribution of the ITS elements on each priority corridor, a tailored data, voice, and video communications and spectrum analysis should be conducted to determine the ITS network requirements for the City of Lincoln ITS communication system.

6.2 ITS User Needs

During this phase of the project, the City of Lincoln's ITS goals and objectives and ITS user needs were identified. The foundation has effectively been laid for the next important step in the ITS strategic planning process: the development of the regional architecture. The first step in this process is the development of User Services and Market Packages. Using the National ITS Architecture precepts and definitions, the development of the Market Packages will define the "elements" of the City's regional architecture. In addition, performance measures will be defined to help guide the City toward an effective regional architecture.

Performance measures, as they relate to ITS planning, engineering and deployment, are used to determine the success or potential success of ITS. In most ITS strategic plans, these measures are directly related to identified needs or goals and objectives, derived on input from transportation system users, operators and other stakeholders. Thus, the needs, goals and objectives identified as part of this phase will be utilized to establish the performance criteria.

The User Services and Market Packages concept comes from the National ITS Architecture. In short, User Services and Market Packages define ITS building blocks for meeting user needs within the guidelines defined by the National ITS Architecture. Market Packages are tailored to fit, separately or in combination, real world transportation problems and needs identified in this phase of the project.

The User Services and Market Packages identification and selection exercises will utilize a multi-step process similar to the selection of the User Services. The User Services will be mapped to the Market Packages. The end result will be a listing of Market Packages upon which to begin building a Regional Architecture.

Traffic Studies, Evaluations and ITS Planning for Lincoln's Arterial Street System 1999-2000 (Phase II)
Volume II: ITS Communication and User Needs Analysis

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Appendix A
Minutes of Meetings with Local Communication Providers

Appendix B
List of Attendees at ITS Workshops

List of ITS Workshop Attendees
October 14, 1998

Name	Organization
Al Schroeder	Aliant Communications
Bob Morrill	Aliant Communications
Kevin Dowd	Aliant Communications
Sara Bishop	Aliant Communications
Milo Cress	FHWA
Pete Picard	FHWA
Kerry Eagan	Lancaster County
Dave Harnly	Lincoln Police Department
B. Mike Michaelson	Lincoln Public Works & Utilities Department
Bruce Briney	Lincoln Public Works & Utilities Department
Dennis Bartels	Lincoln Public Works & Utilities Department
Jim Visger	Lincoln Public Works & Utilities Department
Kelly Sieckmeyer	Lincoln Public Works & Utilities Department
Larry Jochum	Lincoln Public Works & Utilities Department
Mark Garrett	Lincoln Public Works & Utilities Department
Rick Haden	Lincoln Public Works & Utilities Department
Scott Opfer	Lincoln Public Works & Utilities Department
Virendra Singh	Lincoln Public Works & Utilities Department
Abbas Mohaddes	Meyer, Mohaddes Associates
Ramin Massoumi	Meyer, Mohaddes Associates
Jim McGee	Nebraska Department of Roads
Jim Pearson	Nebraska Department of Roads
Karl Fredrickson	Nebraska Department of Roads - Design
Jeff Gast	Sen. Wesely's Leg. Aide
Brian Praeuner	StartTran/Public Works
Duane Eitel	The Schemmer Associates
Linda Weaver Beacham	The Schemmer Associates
Mark Lutjeharms	The Schemmer Associates
Roger Wozny	The Schemmer Associates
Ron Woracek	The Schemmer Associates
Bill Tobin	University of Nebraska
Pat McCoy	University of Nebraska

List of ITS Workshop Attendees
December 1, 2000

Name	Organization
Diane Gonzolas	Citizen Information Center (CIC)
Steve Huggenberger	City Attorney
Tim Pratt	City of Lincoln Engineering Services
Don Herz	City of Lincoln Finance Department
Doug Thomas	City of Lincoln Information Services
Steve Hiller	City of Lincoln Parks & Recreation
John E. Cripe	City of Lincoln Personnel
Mike Brienzo	City of Lincoln Planning Department
Hassan Eltayeb	City of Lincoln Urban Development
Marc Wullschleger	City of Lincoln Urban Development
Doug Pillard	Lancaster County Engineering
Carol Connor	Lincoln City Library
Cliff Dale	Lincoln Public Schools
Don Freeman	Lincoln Public Schools
Kirk Langer	Lincoln Public Schools
Dave Bernt	Lincoln Public Works & Utilities Department
Dennis Bartels	Lincoln Public Works & Utilities Department
Jim Visger	Lincoln Public Works & Utilities Department
Larry Jochum	Lincoln Public Works & Utilities Department
Margaret Remmenga	Lincoln Public Works & Utilities Department
Mark Garrett	Lincoln Public Works & Utilities Department
Roger Figard	Lincoln Public Works & Utilities Department
Scott Opfer	Lincoln Public Works & Utilities Department
Shane Dostal	Lincoln Public Works & Utilities Department
Virendra Singh	Lincoln Public Works & Utilities Department
Abbas Mohaddes	Meyer, Mohaddes Associates
Marc Porter	Meyer, Mohaddes Associates
Ramin Massoumi	Meyer, Mohaddes Associates
Paul M. Cammack	Nebraska Department of Roads
Randy Peters	Nebraska Department of Roads
Jim McGee	Nebraska Department of Roads Transportation Technology
Bill Hobbs	Nebraska State Patrol
Glenn Knust	StarTran
Mark Stevens	StarTran
Mike Jeffres	State of Nebraska – Division of Communications
Linda Beacham	The Schemmer Associates
Mark Lutjeharms	The Schemmer Associates
Mark Pohlmann	The Schemmer Associates

List of ITS Workshop Attendees
February 27, 2001

Name	Organization
Julie Righter	911
David Norris	Citizen Information Center (CIC)
Tim Pratt	City of Lincoln Engineering Services
Don Herz	City of Lincoln Finance Department
Jim Weverka	City of Lincoln Health / Animal Control
Kathy Cook	City of Lincoln Health / Animal Control
Doug Thomas	City of Lincoln Information Services
Steve Hiller	City of Lincoln Parks & Recreation
Terry Genrich	City of Lincoln Parks & Recreation
Mike Brienzo	City of Lincoln Planning Department
Jim Peschong	City of Lincoln Police Department
Larry Schauer	City of Lincoln Purchasing
Marc Wullschleger	City of Lincoln Urban Development
Gary Miller	Lincoln City Library
Don Freeman	Lincoln Public Schools
Fred Craigie	Lincoln Public Schools
Allan Abbott	Lincoln Public Works & Utilities Department
Bill Nass	Lincoln Public Works & Utilities Department
Dave Bernt	Lincoln Public Works & Utilities Department
Jim Huff	Lincoln Public Works & Utilities Department
Jim Visger	Lincoln Public Works & Utilities Department
Larry Jochum	Lincoln Public Works & Utilities Department
Mark Garrett	Lincoln Public Works & Utilities Department
Roger Figard	Lincoln Public Works & Utilities Department
Scott Opfer	Lincoln Public Works & Utilities Department
Gary Brandt	Lincoln Public Works & Utilities Department – Wastewater
Mark Bauer	Lincoln Public Works & Utilities Department – Wastewater
Marc Porter	Meyer, Mohaddes Associates
Ramin Massoumi	Meyer, Mohaddes Associates
Paul M. Cammack	Nebraska Department of Roads
Randy Peters	Nebraska Department of Roads
Jim McGee	Nebraska Department of Roads Transportation Technology
Rich Ruby	Nebraska Department of Roads, District 1
Glenn Knust	StarTran
Mike Jeffres	State of Nebraska – Division of Communications
Linda Beacham	The Schemmer Associates
Mark Lutjeharms	The Schemmer Associates
Mark Pohlmann	The Schemmer Associates